

**NIOSH-Interactive RadioEpidemiological Program
Operating Guide**

*****DRAFT*****

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October 15, 2001

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I. General information

NIOSH-IREP (version 4.0b) is an internet-based software tool to be used by the Department of Labor in estimating the probability that a cancer was caused by workplace exposure to ionizing radiation¹, as required under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA) of 2000, as specifically implemented by DHHS 42 CFR Part 81. More information about the development of NIOSH-IREP may be found in the documents entitled “NIOSH-Interactive RadioEpidemiological Program Documentation”, and “Proposed Radiation Weighting Factors for Use in Calculating Probability of Causation of Cancers”, both of which can be found at the following web site: <http://www.cdc.gov/niosh/ocas/ocasirep.html#irep>. Version 4.0b of NIOSH-IREP is currently under review and thus is subject to further revision and updating. This version is being made available for public use to provide an opportunity to review and critique the procedure used to calculate the probability that a diagnosed case of cancer was caused by past exposure to radiation. The public may comment on NIOSH-IREP at any time. Comments can be sent electronically by e-mail to ocas@cdc.gov. The preferred formats for electronic documents sent by e-mail are MS Word or WordPerfect. Comments can be mailed to: NIOSH-IREP Comments, National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, 4676 Columbia Parkway, Mailstop R-45, Cincinnati, Ohio 45226.

¹This is called “Probability of Causation”, or sometimes “Assigned Share” in the NIOSH-IREP software. For purposes of compensation under EEOICPA, these terms are used interchangeably.

This document provides instructions on how to use NIOSH-IREP to estimate the probability of causation under EEOICPA. These instructions have been developed explicitly for the Department of Labor in conducting a claim analysis of probability of causation; however, it is likely that others may be interested in using NIOSH-IREP. As a result, these instructions indicate which pieces of information are required for the operation of NIOSH-IREP, and which are required only for the Department of Labor to formally estimate the probability of causation for a given cancer.

For the period of public evaluation, the NIOSH-IREP program interface is located at the NIOSH Office of Compensation Analysis and Support (OCAS) web site (<http://www.cdc.gov/niosh/ocas/ocasirep.html#irep>).

II. Creating a file for a claim

A. Information needs

Compile all the information you will enter into NIOSH-IREP to calculate probability of causation for an individual claim

The NIOSH-IREP output file contains all information required to duplicate a calculational run. An output file may be saved to a hard disk, but at the present time, the claim inputs may not be saved. For this reason, the claim input information must be complete before beginning the process, in order to document a claim. If you are calculating probability of causation for a person with multiple primary cancers, a type of leukemia, or

an unspecified primary cancer, you will calculate multiple probability of causation estimates. This will require you to run NIOSH-IREP more than one time, entering data separately for each run, which will employ a different cancer model. In these cases involving multiple probability of causation estimates, you only need complete information to calculate a single estimate, because you will be restarting the program and creating a new data file before you can move on to the second and any subsequent estimates. The following is a checklist for the information you may need to run NIOSH-IREP:

NIOSH-IREP Information Checklist

- _____ Claimant name (DOL use only)
- _____ DOL Claim number (DOL use only)
- _____ Claimant SSN (DOL use only)
- _____ DOL Claim Center (DOL use only)
- _____ Claimant gender
- _____ Claimant year of birth
- _____ Claimant year of primary cancer diagnosis
- _____ Claimant primary and secondary cancer diagnoses (ICD-9 coded)
- _____ Claimant ethnicity (skin cancer claims only)
- _____ Claimant smoking history prior to primary cancer diagnosis (lung cancer claims only)
- _____ DOE workplace radon exposure history of claimant, in units of working level months (lung cancer claims only)

_____ Other DOE workplace ionizing radiation exposure history of claimant, in units of cSv (rem)

B. Creating a claim

To begin creating an output file for a claim, left-click with your mouse on the word “BEGIN” at the main screen, entitled “NIOSH-IREP Version 4.0b For Estimating Probability of Cancer Causation for Exposures to Radiation”, located at http://216.82.51.38/irep_niosh/.

C. Entering claim information into NIOSH-IREP

The first screen encountered is entitled “Probability of Cancer Causation from Exposure to Radiation”. The date of the program run will automatically appear near the top of the page. Spaces appear with information to enter the claimant’s personal information, cancer diagnosis information, and exposure information. When a program run is initiated, these spaces are filled with example information, which you will replace with claimant-specific information as described below.

1. Claimant Personal Information

a. *Claimant name (Required for DOL use only)*

Place the cursor inside the white box (field) next to “Claimant name:” Replace the default value in the field with the claimant name.

The claimant name will be printed on the output report exactly as it is entered.

b. Claim number (Required for DOL use only)

Enter the claim number established by the Department of Labor.

c. Claimant SSN (Required for DOL use only)

Enter the claimant's social security number (SSN).

This serves as a confirmation of claimant identity (in addition to the name and claim number)

d. DOL Claim Center (Required for DOL use only)

Enter the Department of Labor Claim Center (Cleveland OH, Denver CO, Jacksonville FL, or Seattle WA) from which the claim was received.

e. Gender

Select the claimant's gender (male or female) from the pull-down menu.

f. Birth Year

Enter the claimant's year of birth. This field requires a four-digit numeric (year) format.

2. Claimant cancer information

a. Year of Diagnosis

Enter the year of diagnosis of the primary cancer for which the probability of causation cancer is to be estimated. This field requires a four-digit numeric (year) format.

b. Claimant Cancer Diagnoses

Using the mouse, left-click on “Enter Diagnoses”. The next screen is entitled “Enter Cancer Diagnosis Information”. List the first primary cancer, along with its ICD-9 code, in the field next to “Primary Cancer #1”. Repeat this step for up to two more primary cancers and three secondary cancers. Enter the date of diagnosis in the field next to the cancer entry.

This table is provided so that the cancer(s) experienced by the claimant will be identified in the summary output report. This entry is not used for calculations.

c. Cancer model selection

Select the appropriate cancer model from the pull-down menu, as directed in Table 1. The cancers are listed in the pull-down menu in order of ICD-9 code. If a secondary cancer site has been identified with no primary cancer site known for this secondary cancer, you will need to identify the primary cancer site to select in Table 1, as explained below.

Table 1 identifies the model to be used in NIOSH-IREP for each primary cancer associated with a claim. Each primary cancer would require a separate run of NIOSH-IREP to produce a separate probability of causation estimate. For a claim in which more than one primary cancer is identified, you would conduct multiple independent runs of NIOSH-IREP employing the appropriate separate cancer models, and upon completion of these multiple runs apply a statistical formula to combine the multiple probability of causation estimates into a single estimate. This

single estimate will approximate the probability that at least one of the primary cancers was caused by the radiation exposures (see DHHS 42 CFR 81.25).

Likewise, for claims involving some leukemia types or certain carcinomas in situ, you would perform more than one run of NIOSH-IREP to produce probability of causation estimates employing differing cancer models. In these cases, DOL will use the model producing the highest probability of causation at the upper 99% credibility limit as a basis for the compensation decision.

If the primary cancer site is unknown, but a secondary site is known, consult Table 2 to identify the probable primary cancer site(s). Then use the primary site(s) identified, referring to Table 1, to select the appropriate cancer model. If multiple primary cancer sites are identified, you will conduct multiple runs of NIOSH-IREP using the appropriate models separately and DOL will base its compensation decision on the model producing the highest probability of causation at the upper 99% credibility limit

d. Should alternate cancer model be run? (Required for DOL use only)

Left-click with your mouse in the “Yes” field if you will need to complete multiple runs of NIOSH-IREP to produce probability of causation estimates employing differing cancer models.

As discussed above, for certain primary cancers in cases when a claimant has more than one primary cancer, and in certain cases when you have identified

primary cancer sites for claims in which the primary cancer site was unspecified, more than one NIOSH-IREP cancer model must be run. This field should be flagged “Yes” if a claim meets one of these criteria, serving as a reminder to the claim processor that more than one cancer model should be run. The claim processor is responsible for identifying which situations require more than one probability of causation claim to be run.

It is also important to note that the dose reconstruction inputs will likely change for some alternative cancer models. If this is the case, the NIOSH dose reconstruction procedure will provide and clearly identify the input relating to each primary cancer site.

3. Inputs for Skin and Lung Cancer Only (Includes Radon Exposure to Lung)

a. *Skin cancer Inputs (Required for NIOSH-IREP–skin cancer claims only)*

Select the ethnic origin(s) identified in the claim from the pull-down menu.

For skin cancer only, ethnic origin is incorporated into the estimates of background U.S. incidence of skin cancer, which affects the probability of causation. If the primary diagnosis is malignant melanoma (ICD-9 172), or other malignant neoplasm of skin (ICD-9 173), the race or ethnic identification of the claimant must be selected from the pull-down menu. The selection options for race and ethnic origin are:

1. American Indian or Alaska Native
2. Asian, or Native Hawaiian or Other Pacific Islander

3. Black
4. White–Hispanic
5. White–Non-Hispanic

If a claimant self-identifies as more than one ethnicity for a skin cancer claim, then the probability of causation must be estimated separately for each ethnic group, and DOL will use the estimate producing the highest probability of causation in deciding the claim. For cancers other than skin, ethnicity information should not be entered by the user and would have no effect if entered.

b. Lung Cancer Inputs (Required for NIOSH-IREP– trachea, bronchus and lung cancer claims only)

NIOSH-IREP includes a special risk model for lung cancer caused by exposure to radon. The risk produced by exposure to radon is combined within NIOSH-IREP with risks from exposures to other types of radiation, but the information is entered separately by the user. In this screen, information about the sources of exposure used for lung cancer is entered, and if applicable, the radon exposure information is also entered. For other types of cancers, this information should not be entered by the user and would have no effect if entered.

Under “Lung Cancer Inputs:” in the field called “Exposure from:”, select the type of exposure that will be used for the primary lung cancer probability of causation calculation.

The exposure type options are “Radon” (to be used if radon is the only type of exposure of the claimant), “Other Sources” (to be used if the claimant had other types of exposure, but not radon), and “Radon + Other Sources”. It is important that the correct option is selected here, because the probability of causation calculation will incorporate only the exposure types indicated here.

For claimants with trachea, bronchus or lung cancer who were exposed to radon, enter the number of radon exposures in the field entitled “Number of Radon Exposures:”.

Click the button entitled “Radon Exposure Information” to enter these radon doses.

The program will generate a number of exposure input lines equal to the number of radon exposures entered in the previous screen.

For each exposure, enter the exposure year (4-digit year format).

Select from the pull-down menu the exposure type and the distribution type provided by NIOSH.

There are five distribution types in NIOSH-IREP. More information about these distribution types can be found by clicking on the blue “Help” button on this screen.

Enter the appropriate distribution parameter in the fields labeled “1”, “2” and “3”. If a single number is to be entered, use the distribution type labeled “Constant(value)”, and enter the exposure value in the field labeled “1”. The unit of dose used for radon exposures is working level month (WLM).

When all radon exposures have been entered, press “Submit Dose Data”.

In the field “Smoking history:”, select from the pull-down menu the appropriate category as it applies to the claimant.

For primary trachea, bronchus and lung cancer only (ICD-9 code 162), NIOSH-IREP includes an adjustment for smoking status and level. In the field “Smoking history:”, select from the pull-down menu the appropriate category as it applies to the claimant. The categories include:

- a. Never smoked. This category should be selected for claimants who have smoked no more than 100 cigarettes before the date of cancer diagnosis.
- b. Former smoker. This category should be selected for claimants who quit smoking more than five years before the date of cancer diagnosis.

- c. Current smoker (? cig/day). This category should be selected for claimants who were current smokers at the time of the cancer diagnosis (or who quit fewer than five years before the date of cancer diagnosis), whose level of cigarette consumption is unknown.
- d. <10 cig/day (currently). This category should be selected for claimants who were current smokers at a level of 1-9 cigarettes per day at the time of the cancer diagnosis (or who quit fewer than five years before the date of cancer diagnosis).
- e. 10-19 cig/day (currently). This category should be selected for claimants who were current smokers at a level of 10-19 cigarettes per day at the time of the cancer diagnosis (or who quit fewer than five years before the date of cancer diagnosis).
- f. 20-39 cig/day (currently). This category should be selected for claimants who were current smokers at a level of 20-39 cigarettes per day at the time of the cancer diagnosis (or who quit fewer than five years before the date of cancer diagnosis).
- g. 40+ cig/day (currently). This category should be selected for claimants who were current smokers at a level of 40 or more cigarettes per day at the time of the cancer diagnosis (or who quit fewer than five years before the date of cancer diagnosis).

4. Entering dosimetry information (non-radon)

a. Overview

There are two different methods for entering dosimetry information into NIOSH-IREP: a manual dose entry procedure, and the importation of an electronic file. The latter method is intended for the Department of Labor to use in processing claims; however, identical results are received by using manual and electronic data entry. At the present time, only manual dosimetry entry is possible.

When the claimant's primary cancer is of the trachea, bronchus or lung (ICD-9 162), there is an extra step that must be used when inputting dose, regardless of whether the dose entry is manual or electronic. The user must enter information about radon exposure separately, according to the procedure described in Section II.C.3.b above.

Besides radon, NIOSH-IREP includes eleven types of radiation exposure, described in Table 3. There are two classes of electron (beta particle) exposure within NIOSH-IREP, one class associated with exposure to tritium, and a second class for all other electrons. Three different photon energy classes exist within NIOSH-IREP: photons of energy greater than 200 keV (typical of most photon exposure of the DOE workforce), photons of energy between 30 and 200 keV, which includes photofluorographic X rays used during the 1940s and 1950s at some Department of Energy (DOE) facilities, and photons of energy less than 30 keV, which includes photons emitted by certain transuranic radionuclides. There are five classes of neutrons differentiated by energy type. The most commonly encountered type of neutron exposure within the DOE

workforce is fission neutrons, composed primarily of neutrons with energy between 100 keV and 2 MeV. However, neutrons of higher and lower energy are included because these exposures are relevant for certain DOE workers. Finally, a single class of radiation exposure is included for non-radon alpha particles.

b. Dose input using manual entry

Go to the section on the main screen entitled “Exposure Information.”

Enter the number of total occupational exposures (not including radon) in the field called “Number of Exposures”.

Each exposure type (for example, gamma, neutron, and alpha) for each badging period is considered a separate exposure, even if there is more than one value per year for the same type of exposure.

With the mouse, left-click the button labeled “Enter Doses”.

The program will generate a number of exposure input lines equal to the number of exposures entered in the previous screen.

For each exposure, enter the exposure year (4-digit year format). Select from the pull-down menu the exposure type (chronic or acute), and the radiation type, as specified in the NIOSH dose reconstruction report.

Enter the distribution type for the Organ Dose, in the field entitled “Organ Dose (cSv)”.

There are five distribution types in NIOSH-IREP. More information about these distribution types can be found by clicking on the blue “Help” button on this screen.

Enter the appropriate distribution parameters in the fields labeled “1”, “2” and “3”. If a single dose number is to be entered (i.e., no uncertainty in dose is assumed), use the distribution type labeled “Constant(value)”, and enter the exposure value in the field labeled “1”.

All units for non-radon exposures are in units of cSv (rem).

When all non-radon exposures have been entered, left-click on “Submit Dose Data”.

c. Dose input using input file

This feature is not yet available in NIOSH-IREP.

5. Other Advanced Features (Required for DOL use only)

After entering the dosimetry information, press the button labeled “Other Advanced Features”. In the field labeled “Simulation Sample Size”, enter 2000. If the resulting 99th percentile estimate of the probability of causation is 45% or

greater, then the entire NIOSH-IREP run for that calculation should be repeated, using a “Simulation Sample Size” of 10,000.

The default simulation sample size to be used by DOL in calculating the probability of causation is 2000. Because the probability of causation distribution is a random sample generated by propagating all the uncertainties of the input data and the underlying risk models, the distribution parameters on the probability of causation estimate may change slightly when repeat runs are done (using a different random number seed). This variability is greatest at the tails of the distribution of probability of causation (such as at the upper 99th percentile), and may be reduced by increasing the simulation sample size in NIOSH-IREP. Doing this, however, greatly increases the time required to perform the calculation, and may reduce the number of concomitant users of the software because of the increased computational demand. *Therefore, the default number of simulations to be used is 2000, and in instances where the upper 99th percentile estimate of the probability of causation is close to 50% , the number of simulations to be used will be increased to 10,000.* For non-DOL users of the software, the current field default of 1000 simulations will be adequate for purposes of software evaluation.

Generate a random number between 1 and 999,999, and enter it into the field labeled “Random Seed”.

DOL will change the value of the random number seed each time a new probability of causation calculation is performed. The random number may be selected from a random number table, or using a commercial software package such as SAS, Microsoft-Excel, or Lotus spreadsheet.

The User Defined Uncertainty Distribution must be left at the default values.

6. Output from NIOSH-IREP

a. Generate Results Report

Left-click with your mouse on the button entitled “Summary Report”, under “Generate Results Report”.

After several minutes, during which calculations are being performed, NIOSH-IREP will generate a claimant output file. An example of this report is provided in the Appendix. This report contains sufficient information about the claim to be able to reproduce the NIOSH-IREP run exactly. The probability of causation distribution is provided at the end of the report. DOL will use the upper 99th percentile of this distribution to determine whether the cancer of the employee represented in the claim was at least as likely as not (a probability of causation finding of greater than or equal to 50.0%) to have resulted from the workplace exposures to ionizing radiation. This file may be printed by using the “File/print” feature of the user’s internet browser.

b. Generate Intermediate Results and Importance Analysis

Some advanced users evaluating the NIOSH-IREP software may be interested in viewing intermediate results, including the calculated individual absorbed dose, the relative biological effectiveness factor, and the excess relative risk for each exposure. This information, along with an evaluation of the contribution of various factors to the uncertainty about the probability of causation, is available by clicking the button on the main screen, entitled "Intermed Results".

III. Technical Information and Assistance

A. About NIOSH-IREP

The Interactive RadioEpidemiological Program (IREP) is a computer code initially developed at the request of the National Cancer Institute (NCI) as part of the effort to update the 1985 Radioepidemiological Tables report. The 1985 report was mandated by the 1983 "Orphan Drug Act" (PL 97-414) which instructs to "devise and publish radioepidemiological tables that estimate the likelihood that persons who have or have had any of the radiation-related cancers and who have received specific doses prior to the onset of such disease developed cancer as a result of these doses."

This version of IREP (NIOSH-IREP v.4.0b) has been created in support of one of the Institute's roles in implementing the "Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA)." The Act provides a framework for compensating workers involved in the U.S. nuclear weapons programs who have developed a disease as a result of their occupational exposure to radiation and other contaminants. Within this

framework, NIOSH has the lead role within the U.S. Department of Health and Human Services (HHS) in developing guidelines by which the U.S. Department of Labor (DOL) will determine the probability that a cancer of a nuclear weapons production worker was caused by occupational exposure to radiation. The guidelines, proposed for public comment on October 5, 2001 in the Federal Register [see FR 66(194):50967-50978; HHS Notice of Proposed Rulemaking; Guidelines for Determining Probability of Causation under EEOICPA), are required to make use of current versions of the Radioepidemiological Tables, together with other information germane to the radiation exposure experiences of nuclear weapons production workers. Using the guidelines, DOL is directed by EEOICPA to determine whether a cancer presented in a claim for compensation was "at least as likely as not" caused by the worker's occupational exposure to radiation at the 99th percentile credibility limit of the RadioEpidemiological Tables. The NIOSH-IREP computer code has been developed for this purpose.

NIOSH-IREP contains a collection of risk coefficients for cancer incidence obtained mainly from the Japanese A-bomb survivors study, but also from other epidemiological studies. The risk coefficients are adjusted for random and systematic errors in the A-bomb survivors dosimetry, and they are adapted for the U.S. population. Appropriate adjustments of the coefficients are made for low dose and low dose-rate exposure situations common to nuclear weapons production work. The uncertainties in every component are fully expressed and propagated.

Version 4.0b of NIOSH-IREP is currently under technical and scientific review and thus subject to further revision and updating. This version is being made available for public use to provide an opportunity to review and critique the procedure used to calculate the probability that a diagnosed case of cancer was caused by past exposure to radiation. During the public comment period (October 5, 2001 - December 4, 2001) of the “Notice of proposed rulemaking” for 42 CFR Part 81, written comments may be submitted electronically by e-mail to NIOCINDOCKET@CDC.GOV or printed comments may be submitted to the following address: NIOSH Docket Office, Robert A. Taft Laboratories; M/S C34, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Users of this version of NIOSH-IREP who wish to communicate suggestions for improvement after the public comment period (December 5, 2001 or thereafter) may do so directly to NIOSH (ocas@cdc.gov). NIOSH will make available for use by DOL and the public an operative version of NIOSH-IREP incorporating improvements suggested by scientific and public reviews, as soon as HHS promulgates a final rule on probability of causation determinations under EEOICPA (42 CFR Part 81), expected in April, 2002.

B. Help and informational screens

NIOSH-IREP is designed to be self-documenting. Information about the appropriate types of input may be obtained by clicking on the Help button at each screen, or by pausing the mouse over the field (a yellow “pop-up” help screen appears for key fields such as the exposure parameter fields). The details underlying the models may be examined by clicking

“View Model Details” from the main screen. This model documentation will be continuously improved throughout the software evaluation period.

C. Contact information

Technical information about NIOSH-IREP may be obtained, and comments about NIOSH-IREP may be made, by contacting the NIOSH Office of Compensation Analysis and Support (OCAS) by e-mail at ocas@cdc.gov, or by mail at:

NIOSH-IREP

NIOSH Office of Compensation Analysis and Support

4676 Columbia Pkwy, MS-R45

Cincinnati, OH 45226

Table 1. Cancer selection for calculation of probability of causation. Abbreviations: MN (malignant neoplasm), CIS (carcinoma in situ), NUB (neoplasm of uncertain behavior), NUN (neoplasm of unspecified nature).

Primary neoplasm	ICD-9 code	NIOSH-IREP model for calculating PC
Malignant neoplasm (MN) of lip, oral cavity and pharynx	140-149	Oral cavity and pharynx
MN of esophagus	150	Esophagus
MN of stomach	151	Stomach
MN of small intestine	152	All digestive
MN of colon	153	Colon
MN of rectum and anus	154	Rectum
MN of liver	155.0, 155.2	Liver
MN of gall bladder and bile ducts	155.1, 156	Gall bladder
MN of pancreas	157	Pancreas
MN of retroperitoneum and peritoneum	158	All digestive
MN of other digestive	159	All digestive
MN of nasal cavities, middle ear, and sinuses	160	Other respiratory
MN of larynx	161	Other respiratory
MN of trachea, bronchus and lung	162	Lung
MN of pleura	163	Other respiratory
MN of thymus, heart and mediastinum	164	Other respiratory

Primary neoplasm	ICD-9 code	NIOSH-IREP model for calculating PC
MN of other respiratory organs	165	Other respiratory
MN of bone	170	Bone
MN of connective tissue	171	Connective tissue
Malignant melanoma	172	Malignant melanoma
MN of other skin	173	Non-melanoma skin
MN of breast	174, 175	Breast
MN of uterus or uterine cervix	179, 180, 182	Female genitalia less ovary
MN of ovary	183	Ovary
MN of other female genital	181, 184	Female genitalia less ovary
MN of male genital	185-187	All male genitalia
MN of urinary bladder	188	Bladder
MN of kidney and other urinary organs	189	Urinary organs less bladder
MN of eye	190	Eye
MN of brain and other nervous system	191, 192	Nervous system
MN of thyroid gland	193	Thyroid
MN of other endocrine glands	194	Other endocrine glands
MN of other and ill-defined sites	195	Other and ill-defined sites
Non-Hodgkin's lymphoma and other lymphoid tissue, Hodgkin's disease	200-202	Lymphoma and multiple myeloma
Multiple myeloma and other immunoproliferative diseases	203	Lymphoma and multiple myeloma

Primary neoplasm	ICD-9 code	NIOSH-IREP model for calculating PC
Acute and unspecified lymphocytic leukemia	204.0, 204.9	Acute lymphoid leukemia
Subacute and other (not chronic) lymphoid leukemia	204.2, 204.8	Leukemia, less CLL
Acute and unspecified myelogenous leukemia	205.0, 205.9	Leukemia, less CLL AND Acute myeloid leukemia
Chronic myelogenous leukemia	205.1	Leukemia, less CLL AND Chronic myeloid leukemia
Subacute myelogenous leukemia, myeloid sarcoma, and other myeloid leukemia	205.2, 205.3, 205.8	Leukemia, less CLL
Monocytic leukemia, other specified leukemia	206, 207	Leukemia, less CLL
Acute leukemia of unspecified cell type	208.0	Leukemia, less CLL AND Acute lymphoid leukemia, AND Acute myeloid leukemia
Chronic leukemia of unspecified cell type	208.1	Leukemia, less CLL AND Chronic myeloid leukemia
Carcinoma in situ (CIS) of lip, oral cavity and pharynx	230.0	Oral cavity and pharynx
CIS of esophagus	230.1	Esophagus
CIS of stomach	230.2	Stomach
CIS of colon	230.3	Colon
CIS of rectum, anal canal, and anus	230.4, 230.5, 230.6	Rectum
CIS of liver and biliary system	230.8	Liver
CIS of other and unspecified intestine, digestive organs	230.7, 230.9	All digestive

Primary neoplasm	ICD-9 code	NIOSH-IREP model for calculating PC
CIS of larynx and other respiratory	231.0, 231.8, 231.9	Other respiratory
CIS of lung	231.1, 231.2	Lung
CIS of skin	232	Malignant melanoma AND Non-melanoma skin
CIS of breast	233.0	Breast
CIS of cervix uteri or other and unspecified parts of uterus	233.1, 233.2	Female genitalia, less ovary
CIS of other and unspecified female genital organs	233.3	Female genitalia, less ovary AND Ovary
CIS of prostate, penis or other and unspecified male genital organs	233.4	All male genitalia
CIS of bladder	233.7	Bladder
CIS of other and unspecified urinary organs	233.9	Urinary organs less bladder
CIS of eye	234.0	Eye
CIS of other and unspecified sites	234.8, 234.9	Other and ill-defined sites
Neoplasm of uncertain behavior (NUB) of salivary gland, lip, oral cavity or pharynx	235.0, 235.1	Oral cavity and pharynx
NUB of stomach	235.2	Stomach
NUB of colon	235.2	Colon
NUB of rectum and anus	235.2	Rectum
NUB of liver and biliary passages	235.3	Liver

Primary neoplasm	ICD-9 code	NIOSH-IREP model for calculating PC
NUB of retroperitoneum and peritoneum, and other and unspecified digestive organs	235.4, 235.5	All digestive
NUB of larynx, pleura, thymus, mediastinum, and other and unspecified respiratory organs	235.6, 235.8, 235.9	Other respiratory
NUB of trachea, bronchus and lung	235.7	Lung
NUB of uterus, and other and unspecified female genital organs	236.0, 236.1, 236.3	Female genitalia, less ovary
NUB of ovary	236.2	Ovary
NUB of prostate, testis and other male genital	236.4, 236.5, 236.6	All male genitalia
NUB of bladder	236.7	Bladder
NUB of other and unspecified urinary tract, and suprarenal gland	236.9, 237.2	Urinary organs less bladder
NUB of pituitary, pineal and other and unspecified endocrine glands	237.0, 237.1, 237.4	Thyroid
NUB of paraganglia, brain and spinal cord, and other nervous system	237.3, 237.5, 237.6, 237.7, 237.9	Nervous system
NUB of bone and articular cartilage	238.0	Bone
NUB of connective and other soft tissue	238.1	Connective tissue
NUB of skin	238.2	Malignant melanoma AND Non-melanoma skin

Primary neoplasm	ICD-9 code	NIOSH-IREP model for calculating PC
NUB of breast	238.3	Breast
NUB of other lymphatic and hematopoietic	238.5-238.7	Lymphoma and multiple myeloma
NUB of other specified and unspecified sites	238.8, 238.9	Other and ill-defined sites
Neoplasm of unspecified nature (NUN) of digestive system	239.0	All digestive
NUN of respiratory system	239.1	Lung AND Other respiratory
NUN of bone and soft tissue	239.2	Bone
NUN of skin	239.2	Non-melanoma skin
NUN of breast	239.3	Breast
NUN of bladder	239.4	Bladder
NUN of other genitourinary organs	239.5	Female genital less ovary AND Ovary AND All urinary organs (if female) All male genital AND All urinary organs (if male)
NUN of brain and other parts of nervous system	239.6, 239.7	Nervous system
NUN of endocrine glands	239.7	Thyroid AND Other endocrine glands
NUN of other specified or unspecified sites	239.8, 239.9	Other and ill-defined sites

Table 2. Primary cancers (ICD-9 codes²) for which probability of causation is to be calculated, if only a secondary cancer site is known. “M” indicates cancer site should be used for males only, and “F” indicates cancer site should be used for females only.

Secondary cancer	ICD-9 code of likely primary cancers
Lymph nodes of head, face and neck (196.0)	141, 142 (M), 146 (M), 149 (F), 161 (M), 162, 172, 173, 174 (F), 193 (F)
Intrathoracic lymph nodes (196.1)	150 (M), 162, 174 (F)
Intra-abdominal lymph nodes (196.2)	150 (M), 151 (M), 153, 157 (F), 162, 174 (F), 180 (F), 185 (M), 189, 202 (F)
Lymph nodes of axilla and upper limb (196.3)	162, 172, 174 (F)
Inguinal and lower limb lymph nodes (196.5)	154 (M), 162, 172, 173 (F), 187 (M)
Intrapelvic lymph nodes (196.6)	153 (M), 154 (F), 162 (M), 180 (F), 182 (F), 185 (M), 188
Lymph nodes of multiple sites (196.8)	150 (M), 151 (M), 153 (M), 162, 174 (F)
Lymph nodes, site unspecified (196.9)	150 (M), 151, 153, 162, 172, 174 (F), 185 (M)
Lung (197.0)	153, 162, 172 (M), 174 (F), 185 (M), 188 (M), 189
Mediastinum (197.1)	150 (M), 162, 174 (F)
Pleura (197.2)	150 (M), 153 (M), 162, 174 (F), 183 (F), 185 (M), 189 (M)
Other respiratory organs (197.3)	150, 153 (M), 161, 162, 173 (M), 174 (F), 185 (M), 193 (F)
Small intestine, including duodenum (197.4)	152, 153, 157, 162, 171, 172 (M), 174 (F), 183 (F), 189 (M)
Large intestine and rectum (197.5)	153, 154, 162, 174 (F), 183 (F), 185 (M)
Retroperitoneum and peritoneum (197.6)	151, 153, 154 (M), 157, 162 (M), 171, 174 (F), 182 (F), 183 (F)
Liver, specified as secondary (197.7)	151 (M), 153, 154 (M), 157, 162, 174 (F)
Other digestive organs (197.8)	150 (M), 151, 153, 157, 162, 174 (F), 185 (M)

²The International Classification of Diseases Clinical Modification (9th Revision) Volume I&II. [1991] Department of Health and Human Services Publication No. (PHS) 91-1260, U.S. Government Printing Office, Washington D.C.

Secondary cancer	ICD-9 code of likely primary cancers
Kidney (198.0)	153, 162, 174 (F), 180 (F), 185 (M), 188, 189, 202 (F)
Other urinary organs (198.1)	153, 174 (F), 180 (F), 183 (F), 185 (M), 188, 189 (F)
Skin (198.2)	153, 162, 171 (M), 172, 173 (M), 174 (F), 189 (M)
Brain and spinal cord (198.3)	162, 172 (M), 174 (F)
Other parts of nervous system (198.4)	162, 172 (M), 174 (F), 185 (M), 202
Bone and bone marrow (198.5)	162, 174 (F), 185 (M)
Ovary (198.6)	153 (F), 174 (F), 183 (F)
Suprarenal gland (198.7)	153 (F), 162, 174 (F)
Other specified sites (198.8)	153, 162, 172 (M), 174 (F), 183 (F), 185 (M), 188 (M)

Table 3. Radiation exposure types in NIOSH-IREP.

Exposure type	Energy range	Typical exposure scenario
Radon (lung cancer only)	All	Exposure occurs near large sources of radium-bearing material such as the K-65 material at Fernald, or storage of radium in drums.
Electron (source other than tritium)	> 14 keV	Exposure typically results from processing and/or handling of fission products, such as Sr-90, or activation products, such as Co-60. Exposure can also result from uranium handling or processing operations.
Electron (tritium)	$E_{\beta\text{max}} = 14 \text{ keV}$	Exposure typically occurs around tritium production facilities such as Savannah River and Mound, but can also result from nuclear reactor operations or nuclear weapons assembly or research.
Photon	<30 keV	Low-energy x rays from transuranic isotopes such as plutonium.
Photon	30-200 keV	Medium-energy photons are typically encountered from scatter of higher energy photons. These photons can also result from gamma emissions of certain transuranic isotopes such as americium, and are the primary energy found in early stereoscopic x rays.
Photon	>200 keV	High-energy photons are the most common of the three categories listed. These are typically encountered from work with the nuclear fuel cycle from fuel manufacturing, reactor operations, spent nuclear fuel processing, decontamination and decommissioning activities and waste monitoring and storage.
Neutron	<10 keV	Low-energy neutrons exposures include thermal neutrons commonly found around nuclear reactors.
Neutron	10-100 keV	Intermediate-energy neutron exposure can occur around nuclear reactors as neutrons are moderated from high energy to thermal energies.
Neutron (fission)	100 keV-2 MeV	Neutron exposure typically encountered during the operation of a nuclear reactor. This energy of neutron exposure can also be encountered from work with californium neutron sources
Neutron	2-20 MeV	Reactions between alpha particles from materials such as plutonium or polonium and light materials such as beryllium resulting the production of neutrons. These reactions are commonly called (α ,n) reactions. This range also includes 14 MeV neutrons from fusion reactions.
Neutron	>20 MeV	Exposure to neutrons greater than 20 MeV can result from work around accelerators.
Alpha	All	Primary exposure hazard is internal radiation following the inhalation or ingestion of an alpha emitting radionuclides such as plutonium, uranium, americium, polonium, actinium, and thorium.

Appendix: NIOSH-IREP program output

NIOSH-Interactive RadioEpidemiological Program

Probability of Causation Results

Date of run: October 9, 2001DOL Claim Center: Denver, COTime of run: 2:02 p.m.NIOSH-IREP version: 2.1Claim #: 000001-DEClaimant SSN: 000-00-0000Claimant name: John Q. Doe

CLAIMANT CANCER DIAGNOSES:Primary cancer #1: Prostate (ICD-9 185)Date of diagnosis: 10/20/1988Primary cancer #2: N/ADate of diagnosis: N/APrimary cancer #3: N/ADate of diagnosis: N/ASecondary cancer #1: Lung (ICD-9 197.0)Date of diagnosis: 03/13/1994Secondary cancer #2: N/ADate of diagnosis: N/ASecondary cancer #3: N/ADate of diagnosis: N/A

CLAIMANT INFORMATION USED IN PROBABILITY OF CAUSATION CALCULATION:Gender: MRace (skin cancer only): N/ABirth Year: 1920Year of Diagnosis: 1988Cancer model: All male genitaliaShould alternate cancer model be run? NoSmoking history (trachea, bronchus or lung cancer only): N/A

NIOSH-IREP ASSUMPTIONS AND SETTINGS:User-Defined Uncertainty Distribution: Lognormal(1,1)Number of Iterations: 2000Random number seed: 99

EXPOSURE INFORMATION:

Exposure File Name: XXXXXXXXXX

Dose No.	Exposure year	Exposure rate	Radiation type	Organ Dose (cSv)
1	1955	Acute	Photon, E=30-200 keV	Lognormal(0.5,1.8)
2	1955	Acute	Photon, E>200 keV	Lognormal(0.7,1.8)
3	1956	Chronic	Neutron, E=100 keV-2 MeV	Lognormal(0.1,1.8)
4	1956	Acute	Photon, E>200 keV	Lognormal(0.4,2.5)
5	1957	Chronic	Alpha	Uniform(0.1,4)
6	1957	Acute	Photon, E>200 keV	Lognormal(1.3,1.8)
7	1958	Chronic	Alpha	Uniform(0.05,5.6)
8	1958	Acute	Photon, E>200 keV	Lognormal(0.2,1.8)
9	1959	Chronic	Neutron, E=100 keV-2 MeV	Lognormal(0.5,2.5)
10	1959	Acute	Photon, E>200 keV	Lognormal(0.1,1.8)
11	1960	Acute	Photon, E>200 keV	Lognormal(0.5,1.8)
12	1960	Chronic	Neutron, E=100 keV-2 MeV	Lognormal(0.1,2.5)
13	1961	Acute	Photon, E>200 keV	Lognormal(0.3,1.8)
14	1961	Chronic	Neutron, E=100 keV-2 MeV	Lognormal(0.2,2.5)
15	1962	Acute	Photon, E>200 keV	Lognormal(0.1,1.8)

RESULTS OF NIOSH-IREP

Assigned Share (Probability of Causation):

1 st percentile	0.0%
5 th percentile	0.0%
50 th percentile	0.70%
95 th percentile	3.84%
99th percentile	6.84%

Name of Analyst: _____

Title: _____

Signature: _____

Date: _____

Name of Reviewer: _____

_____ Title: _____

Signature: _____

Date: _____